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Original Article

ANALYSIS OF RESPONSE TIME AND TYPE OF STIMULUS IN SCHOOL VOLLEYBALL AND FUTSAL PLAYERS OF BOTH SEXES

ANÁLISE DO TEMPO DE RESPOSTA E DO TIPO DE ESTÍMULO EM ATLETAS DE VOLEIBOL E FUTSAL ESCOLAR DE AMBOS OS SEXOS

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RESUMO
O tempo de resposta de uma ação motora pode ser impactado por fatores como idade, sexo, tipo de estímulo, especificidade motora, entre outros. Esse estudo investigou a diferença nos tempos de reação (TR), de movimento (TM) e de resposta (TTR) em atletas de voleibol e futsal para os sexos e tipo de estímulo. A amostra foi composta de 191 atletas em nível escolar. Utilizou-se o equipamento SPEED com 03 botões de contato e 02 sensores de estimulo [simples (S) e de escolha (E)]. Os resultados mostraram que atletas de voleibol apresentaram menores TR e TTR do que os de futsal, que líberos do voleibol tiveram desempenho superior que os ataques. Já no futsal, goleiros mostraram melhor desempenho que jogadores de linha, porém, goleiros não diferiram dos atletas de voleibol. Atletas masculinos exibiram menores TMS e TTRS que atletas femininos. Estímulo simples reduziu TR e TTR comparado ao estímulo de escolha. Já a mão dominante não afetou os tempos de resposta avaliados. Conclui-se que TR, TM e TTR variaram conforme a modalidade, posição do atleta, sexo e tipo de estímulo.
Palavras-chave: Tempo de movimento. Tempo de reação. Destreza motora. Futebol.

ABSTRACT
The response time of a motor action can be affected by factors such as age, gender, type of stimulus, motor specificity, among others. This study investigated the difference in reaction time (TR), movement time (TM) and response time (TTR) in volleyball and futsal athletes for gender and type of stimulus. The sample consisted of 191 school athletes. The SPEED equipment with 03 contact buttons and 02 stimulus sensors [simple (S) and choice (C)] was used. The results showed that volleyball players had lower TR and TTR than futsal players, and that volleyball liberos performed better than attackers. In futsal, goalkeepers performed better than line players, but goalkeepers did not differ from volleyball players. Male athletes showed lower TMS and TTRS than female athletes. The simple stimulus reduced TR and TTR compared to the choice stimulus. The dominant hand did not affect the response times evaluated. It can be concluded that TR, TM and TTR varied according to sport, athlete position, gender and type of stimulus.
Keywords: Movement time. Reaction time. Motor dexterity. Soccer.

Introduction

A motor response is the action transmitted through efferent neural pathways that pass through the spinal cord, activating motor units to perform the desired motor action[1]. In this context, reaction time (RT) is considered the interval of time to perceive the stimulus, process the information, make a decision, and initiate the response. On the other hand, movement time (MT) is the interval of time between the immediate moment after the initiation of the response and the completion of the motor task, with the sum of RT and MT constituting the total response time (TRT = RT + MT)[2].

Neurophysiology differentiates simple reaction time (TRS) and choice reaction time (TRE), where TRS involves a single kinesthetic stimulus (visual, auditory, and/or tactile) and expects a single response, while TRE involves multiple stimuli requiring the choice of one of the possible responses[2]. Badau *et al.*[3] stated that this response depends on the type, intensity, and nature of the stimulus, as well as the complexity of the task. Silva *et al.*[4]

observed visual TRS values ranging from 150-301ms for these parameters; and Zak *et al.*[5] demonstrated that TRS is normally faster by approximately 100ms compared to TRE.

TR is a complex neuromotor skill influenced by factors such as sex, age, dominant hand, physical fitness, type of stimulus, body maturation, among others[6,7]. Some studies have identified differences in TR and TTR between sexes[8,9]. Spierer *et al.*[9] reported that women exhibit better responses to semantic, verbal, and auditory stimuli, while men respond better to visual and spatial stimuli. Sadler *et al.*[10] found in the literature several studies showing that men are faster than women in TR and TTR. Huerta Ojeda *et al.*[1] found that men were faster than women in TRS and TRE in adolescents aged 15 to 18 years. Nieczuja-Dwojacka *et al.*[11] justified that this difference is due to men's greater muscle mass, while Ervilha *et al.*[12] justified the difference based on the amount of muscle fibers activated by men. However, Otero and Alonso[8] found that women exhibited lower TTR compared to men, which requires further studies to fill this gap.

Athletes exhibit faster TR than non-athletes, with TR varying according to the player's technical level, position on the field, and type of sport. Due to the situational demands of volleyball and futsal, such as ball direction, player movement, tactical and technical actions, which are characterized as open motor skills requiring the athlete to react immediately after an action, making faster decisions is crucial for achieving sporting success.

Volleyball is a sport that predominantly involves hand-eye coordination[14], while futsal predominantly involves foot-eye coordination[13]. However, goalkeepers in futsal also perform hand-eye actions, which could be compared in terms of similarity to volleyball players. In this context, it becomes relevant to evaluate whether there are differences in response times between the positions of volleyball and futsal players.

The TR can be assessed using various software and devices, such as *TRT_S2012*[15] software, *Light Sport Training System*[16], *Grooved Pegboard Test*[17,18], magnetic resonance imaging, neuroimaging, and symptom severity analysis[19], 2D virtual reality environment software*20*, alternating series reaction time task - ASRT[21], among others. The SPEED equipment is a low-cost device composed of contact buttons to start and stop the system's timer, as well as having light stimuli. This equipment differs from other devices by separately measuring the TR, TM, and TTR, demonstrating greater specificity in its assessments.

There are no studies in the literature that evaluate the fractions of TTR (TR + TM) in the upper limbs among athletes from sports modalities characterized by a predominance of hand-eye and foot-eye coordination. Thus, this study investigated, through evaluations with the SPEED equipment, whether there are differences in TR, TM, and TTR of the upper limbs in school athletes of volleyball and futsal regarding sex, types of stimuli, and player positions. The hypothesis of the study is that sex, sports modality, type of stimulus, and player position trigger different TR, TM, and TTR in the upper limbs."

Methods

Sample

The present study had a sample of 191 athletes from volleyball and futsal modalities participating in the Federal Institutes Games (JIF 2019) held in Guarapari-ES, from October 6th to 12th, 2019. The individuals were male and female athletes of the under-19 category teams.

After being properly instructed on the study procedures, the individuals signed the Informed Assent Form (TCLE), and their legal guardians signed the Informed Consent Form

(TALE). The study was approved by the Ethics Committee on Human Research of IF Sudeste MG (Opinion: 4.032.938).

Experimental Design

The present study was characterized as a cross-sectional experimental study, in which individuals participated in a single data collection session, lasting approximately 20 minutes. The assessment procedure was conducted at least 60 minutes prior to the athlete's first game on the same day.

Instrument: SPEED Electronic Equipment

The SPEED electronic equipment was developed by the research group of the Physical Education and Health Department at Rio Pomba campus. The mentioned equipment has a hardware composed of a microprocessor (Microchip model PIC18F4423) to manage the functionalities of the stopwatch. The device measures time in milliseconds (1/100 second) with a frequency of 8MHz, being activated by contact buttons. The evaluation results were displayed on a 2-line by 16-column LCD display, as well as stored in the attached computer's memory.

To begin the timing tests, light stimulus devices were implemented, which emitted a signal at a random moment and activated the stopwatch to start the test. To end the test and turn off the chronometer, it was necessary to press one of the shutdown buttons.

The SPEED equipment was positioned on a table as follows: the contact activation button was placed centrally in front of the subject. The shutdown buttons were positioned at 85% of the reach of the right or left hand, forming a 45º angle with the lateral edge of the table and the individual. The light stimulation sensors were placed beside the shutdown buttons. All contact buttons and light sensors were connected by wires to the central unit of the SPEED equipment (Figure 1).

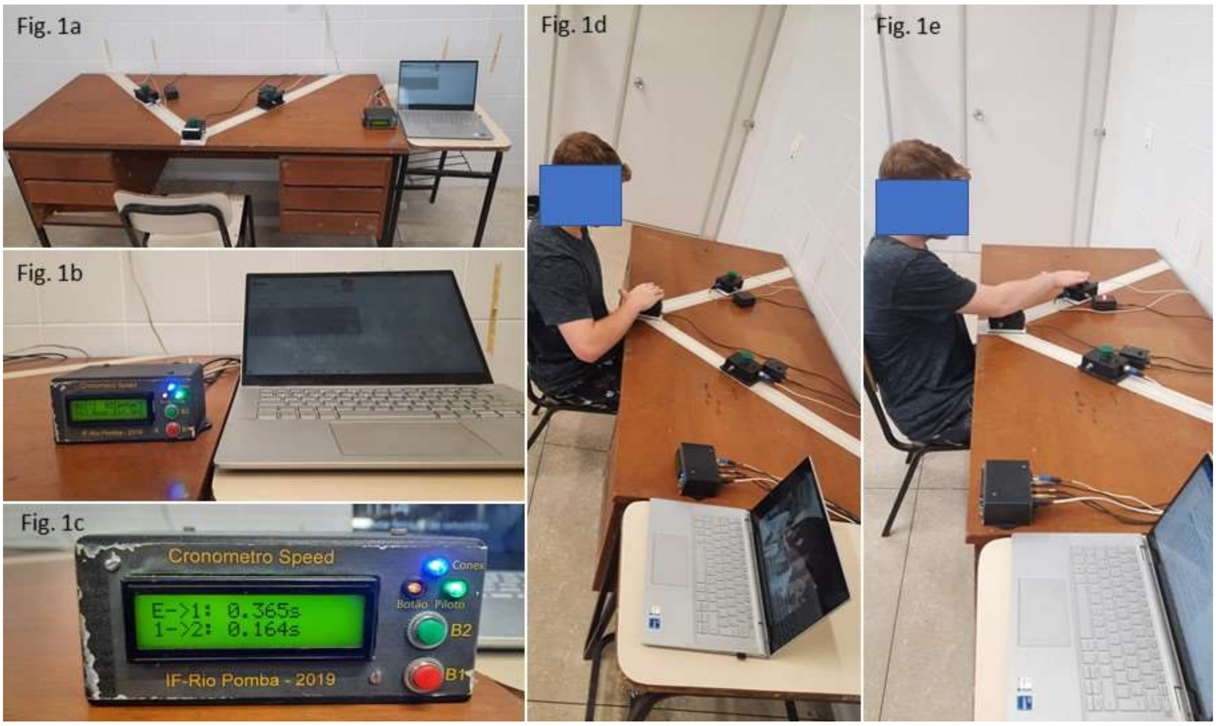

Figure 1. SPEED Equipment. 1a: Arrangement of buttons on the Speed equipment; 1b: LCD

display attached to the notebook via Bluetooth; 1c: Stopwatch of the Speed equipment; 1d: Initial position of the test with the hand on the activation button; 1e: Final position of the test with the hand on the shutdown button after lighting up the light sensor.
Source: authors.

Procedures

Initially, individuals filled out a registration form with personal information. Then, each participant performed 5 tests on the SPEED equipment to assess reaction time (TR), movement time (TM), and total response time (TTR) in simple stimulus (S) or choice (E) situations. Tests 1 to 4 were designed to evaluate TMS, while test 5 was conducted to measure TME.

To assess TR, TMS, and TME, the SPEED equipment with 01 activation button, 02 shutdown buttons, and 02 light stimulus sensors was used. The participants, seated, leaned their backs against the chair's backrest, maintaining a distance of 10 cm from the table and aligning their umbilical line with the activation button (Figure 1d).

The tests were carried out in a controlled environment in order to avoid external interferences on the individuals. Prior to the assessment, the individuals performed the test twice to become familiar with the equipment. Immediately after, they performed the tests twice, recording the fastest time out of the 2 attempts. The study design was adapted from Marinello *et al.*[22].

Reaction Time (TR)

The TR test consisted of measuring the speed at which an individual reacted to a light stimulus by removing their hand from a contact button that triggered the stopwatch of the SPEED equipment. This evaluation was performed in simple stimulus situations (TRS) and choice situations (TRE).

The test started with the individual sitting in a comfortable position facing the activation button. By pressing the activation button with their hand, the SPEED equipment would light up the stimulus light sensor within a time interval between 0.5 and 4.0s. Immediately after the lighting of the stimulus light, the equipment's stopwatch would start. Upon the light signal, the individual should remove their hand from the activation button as quickly as possible, at which point the stopwatch would be stopped.

Simple Movement Time (TMS)

The TMS test consisted of measuring the time it took for an individual to remove their hand from point A (activation button) and move to point B (shutdown button) after the activation of a light stimulus by the SPEED equipment. The TM represents the time interval that begins immediately after the end of the TR and extends until the moment the individual touches the stopwatch's shutdown button, ending the movement.

Tests 1 to 4 were classified as TMS, since the individual already knew on which side (right or left) the light stimulus would be activated. In Tests 1 and 2, participants performed the evaluation with their right hand, moving it to a button on the right (Test 1) and to the left (Test 2). In Tests 3 and 4, the left hand was evaluated, moving it to a button on the left (Test 3) and to the right (Test 4).

Choice Movement Time (TME)

In the TME test (Test 5), the participant pressed the activation button with their dominant hand, without knowing on which side the light stimulus would be activated. After the random activation of the light stimulus, which would turn on within a time interval of 0.5 to 4s, the individual moved their dominant hand until touching the button on the respective side to stop the stopwatch.

Total Response Time (TTR)

The total response time (TTR) was obtained by adding the TR and the TMS or TME in each of the 5 developed tests.

Statistical Analysis

Initially, the data were evaluated using descriptive statistics and presented using frequency measures. For bivariate analysis, after the normality test (*Kolmogorov-Smirnov*), the data were evaluated using ANOVA TWO WAY with Holm-Sidak *post-hoc* test for a 2-factor analysis of variance (Modality x Dominant Hand, Gender x Stimulus), ANOVA ONE WAY with Dunn *post-hoc* test for a 1-factor analysis of variance (positions of volleyball athletes), and Student's t-test (positions of futsal athletes). In the data analysis, Sigma Stat 3.0 software (Systat Software Inc.) was used, with a significance level of 5%.

Results

Table 1 presents the characterization of the study sample. A total of 191 athletes were evaluated, aged between 17-19 years old. Of these individuals, 58.1% were volleyball players and 52.9% were female. The predominance of the right hand as the dominant hand was observed in 93.2% of the athletes, and this proportion was maintained in both volleyball and futsal modalities.

Table 1. Characterization of the study sample

	Variables	Total n (%)	Volleyball n (%) 111 (58.1)	Futsal n (%) 80 (41.9)
Gender	Male	90 (47.1)	58 (52.3)	32 (40.0)
	Female	101 (52.9)	53 (47.7)	48 (60.0)
Age	Male	17.8±0.12	17.7±0.14	17.8±0.19
	Female	17.2±0.11	17.3±0.15	17.2±0.16
Dominant hand	Right	178 (93.2)	103 (92,8)	75 (93.8)
	Left	13 (6.8)	08 (7,2)	05 (6,2)
Position	Striker		81 (73,0)	---
	Setter		21 (18,9)	---
	Libero		09 (8,1)	---
	Line		---	68 (85,0)
	Goalkeeper		---	12 (15,0)

Note: Values are in units for sex, dominant hand, and position. Values are in Mean±SD for age.
Source: authors.

Table 2 presents the results of response times in tests comparing the factors of sports modality and dominant hand. The results of tests 1 to 4 were summed and presented as simple stimulus tests (TRS, TMS, and TTRS), while the results of test 5 were shown as a choice stimulus test (TRE, TME, and TTRE).

To the modality factor, a statistical difference (p<0.05) was observed between the volleyball and futsal modalities. Volleyball athletes displayed shorter times of TRS, TRE, and TTRE compared to futsal athletes.

No significant differences (p>0.05) related to the dominant hand factor were found in any of the evaluated parameters.

Table 2. Reaction times, movement times, and total response times for the factor's modality and dominant hand (in milliseconds).

Times	Factor				Modality	Dominant hand	Modality x Dominant hand
	Modality		Dominant hand				
	Volleyball (n=111)	Futsal (n=80)	Right (n=178)	Left (n=13)	*p*	*p*	*p*
TRS	248±6	270±8*	260±3	257±9	0.028	0.790	0.042
TMS	204±4	201±5	199±2	206±6	0.532	0.251	0.096
TTRS	452±8	470±10	459±3	463±1	0.141	0.733	0.403
TRE	269±10	305±12*	285±4	290±2	0.024	0.754	0.069
TME	188±7	203±9	188±3	202±11	0.188	0.237	0.288
TTRE	457±13	508±17*	473±6	492±21	0.017	0.378	0.055

Note: TRS: simple reaction time, TMS: simple movement time, TTRS: simple total response time, TRE: choice reaction time, TME: choice movement time, TTRE: choice total response time. Values in Mean±SEM. * vs. Volleyball. ANOVA Two-Way with post-hoc Holm-Sidak Test (p<0.05).
Source: authors.

The results of TR, TM, and TTR for the sex and stimulus type factors are presented in Table 3. Regarding the sex factor, the results demonstrated that the male sex exhibited significantly lower values (p<0.05) in TM and TTR tests when compared to females. statistically significant differences were observed. On the other hand, in TR tests, no statistical differences were identified between genders (p>0.05).

In the comparison of the stimulus type factor, it was observed that the choice stimulus resulted in statistically longer RT and TTR times compared to the simple stimulus (p<0.05). On the other hand, in the TM test, the choice stimulus triggered shorter times than the simple stimulus.

Table 3. Reaction times, movement times, and total response time for the factors sex and stimulus (in milliseconds).

Times	Factor				Gender	Stimulus	Gender x Stimulus
	Gender		Stimulus				
	Female (n=101)	Male (n=90)	Simples (n=764)	Choice (n=191)	*p*	*p*	*p*
TR	275±4	268±4	259±2	284±5**	0.177	0.001	0.673
TM	201±2	187±2*	199±1	189±3**	0.001	0.002	0.282
TTR	476±5	455±5*	458±3	472±6**	0.001	0.026	0.850

Note: TR: reaction time, TM: movement time, TTR: total response time, Simples Stimulus (Test 1 + Test 2 + Test 3 + Test 4), Choice Stimulus (Teste 5). Values in Mean±SEM. * *vs*. Female, ** *vs*. Simples. ANOVA Two Way with *post-hoc* Holm-Sidak test (p<0.05).
Source: authors.

The response time results for the players' position factor in the volleyball and futsal modalities are presented in Table 4.

In volleyball modality, it was observed that liberos exhibited statistically lower TRS and TTRS compared to attackers ($p<0.05$). No significant differences were identified for the choice stimulus situations (TRE, TME, and TTRE).

In futsal modality, a significant difference in TRS ($p<0.05$) was observed, where the goalkeeper position showed a lower TRS than the line players. No statistical differences were found in the other analyzed parameters ($p>0.05$).

When comparing the goalkeeper position in futsal with the positions of volleyball players, no significant difference was observed in TR, TM, and TTR in both simple stimulus and choice situations ($p>0.05$).

Table 4. Reaction times, movement times, and total response times for athlete positions in volleyball and futsal modalities (in milliseconds).

Times	Futsal			Volleyball			
	Line (n=68)	Goalkeeper (n=12)	*p*	Attacker (n=81)	Setter (n=21)	Libero (n=09)	*p*
TRS	264±7	253±7*	0.036	261±6	249±6	236±3**	0.018
TMS	202±4	199±3	0.949	198±4	194±5	193±3	0.434
TTRS	466±9	452±8	0.173	461±8	443±7	429±4**	0.033
TRE	306±14	293±22	0.467	273±10	262±15	257±16	0.473
TME	204±10	200±15	0.805	189±8	187±12	181±13	0.781
TTRE	510±18	493±29	0.501	462±13	449±20	437±22	0.447

Note: TRS: simples reaction time, TMS: simples movement time, TTRS: simples total response time, TRE: choice reaction time, TME: choice movement time, TTRE: choice total response time. Values in Mean±SEM. * *vs.* Line, ** *vs*. Simples. ANOVA Two Way with *post-hoc* Holm-Sidak test (p<0.05). * *vs.* Line for Student's t-test. ** *vs.* Attacker, *** *vs.* Goalkeeper for One-Way ANOVA with Dunn's post-hoc Test."
Source: authors.

Discussion

The present study assessed TR, TM, and TTR in actions with simple and choice stimuli for upper limb movements in male and female volleyball and futsal athletes. The TR values in the tests with simple stimuli ranged from 215-297ms, while in the test with choice stimuli they ranged from 252-315ms. Similar values were observed by Hanumantha *et al.*[23], who assessed TR in medical students aged 18-25 years of both sexes, using the Psychology Experiment Building Language software (Version 2.0), and identified TR ranging from 231-397ms. Silva *et al.*[4] observed that TR varied from 150-301ms in futsal goalkeepers. Crocetta *et al.*[15] studied university students aged 18-45 years and found variations in TR between 279-293ms using the TRT_S software. Such findings demonstrate the relevance of the SPEED equipment used in this study, being capable of identifying similar measurements to other equipment and software in tasks with the same degree of complexity, as proposed by other studies[10,24].

The main results of this study showed that volleyball athletes exhibited lower TRS, TRE, and TTRE compared to indoor futsal athletes. Regarding the player position in volleyball, it was identified that liberos exhibited lower TRS and TTRS than attackers; in futsal, goalkeepers showed lower TRS compared to outfield players, however, goalkeepers did not differ in their times from volleyball athletes. Male athletes presented lower TM and TTR compared to female athletes. The simple stimulus resulted in lower TR and TTR compared to the choice stimulus, however, it increased TM. The dominant hand did not affect the evaluated parameters.

In the scientific literature, no studies were found that compared sports with a predominance of hand-eye and foot-eye actions to confront the results of the present study. However, García-de-Alcaraz and Usero[14] stated that the predominance of the hand-eye coordination motor task and the specificity of its training could positively affect the performance of upper limb assessments. Additionally, Huerta Ojeda *et al.*[1] reported that the TTR could be strongly influenced by attention and the specificity of the task developed in their training, conditioned by the maturation of the central nervous system (CNS) and specific modulations in the neural activities of the visual and motor regions in the cerebral cortex.

To not observe differences in TR, TM, and TTR between goalkeepers and players in various positions in volleyball (Table 4), this study suggests that the predominance of actions and specificity of hand-eye coordination training between goalkeepers and volleyball players is the main justification for these athletes to demonstrate similar performances in upper limb assessments, as suggested in previous studies[4,14].

In the volleyball modality, a lower TRS and TTRS was observed among liberos compared to attackers. These results can be explained similarly to those obtained by Maciel *et al.*[25], who, when investigating volleyball athletes aged between 18-39 years, found that middle blockers exhibited lower TR than outside hitters, setters, and opposing attackers. The improved performance of middle blockers was attributed to the blocking functions requiring maximum attention in quickly reading the actions of opposing attackers, which could lead to faster motor performance. This same mechanism can also be attributed to liberos, since they are responsible for reception and defense actions, prioritizing agility to react to the power and speed of opponents' attacks[14]. Normally, liberos undergo specific training sessions to enhance their agility and reaction speed skills, and this training can improve the reaction time through neural adaptations promoted by the high demands of the CNS, enhancing the efficiency of motor reactions4.

The results of the futsal modality revealed that goalkeepers who predominated in their participation with hand-eye coordination actions exhibited lower TRS compared to outfield athletes who only performed foot-eye coordination actions. These findings are in line with the results of previous studies[4,13,26], which reported differences in TR between the positions of futsal athletes due to the greater specificity of goalkeepers' actions and training regarding hand-eye coordination skills, similar to the task evaluated in this study. Ruschel *et al.*[26] demonstrated with soccer athletes that the TR of goalkeepers was lower than that achieved by midfield players, justifying that the goalkeepers' better performance in TR was due to their specific training, which includes a greater amount of reaction speed activities compared to other athletes. Silva *et al.*[27] also provided this rationale when studying the anticipatory TR and TM of goalkeepers in futsal, identifying that action times below 200ms were considered anticipatory actions. In our study, the goalkeepers performed times ranging from 223-297ms, characterizing them as TR rather than anticipation.

Regarding the sex factor, TM and TTR were lower in men than in women, however, no differences were identified in TR. Previous studies have identified similar results[9-12,28], justifying that the lower TTR expressed by men occurred due to differences in muscle fiber size and type, as well as their ability to generate force.

In a meta-analysis, Sadler *et al.*[10] verified in several studies that TTR was lower in men than in women. Spierer *et al.*[9] identified a lower TTR in male soccer players compared to female lacrosse players who performed visual and auditory stimulus tests, justifying that processing speed in a response is an inherent neurological function in humans that differs between sexes and body size. Nieczuja-Dwojacka *et al.*[11] reported that individuals with higher lean muscle mass exhibited better performance in TTR than obese individuals. Ervilha *et al.*[12] stated that TTR would be influenced by the quantity of activated muscle fibers to create movement, which explains the fact that men, due to having larger muscle masses, stimulate more motor units to generate greater force and speed, triggering a faster response than women.

The TR was not affected by the sex of the participants in this investigation; however, men were faster than women in TM and TTR, suggesting that the motor response movement (TM) was more determinant in identifying a lower TTR between sexes. Sadler *et al.*[10] identified a lower TTR in men than in women; however, they did not observe differences in reflex activities, justifying that the difference between sexes would not be explained by variations in response preparation levels, but rather in the execution process of the response. This mechanism could suggest that TTR would be more influenced by morphological parameters, such as differences in muscle mass and/or task training level, than the TR itself[27].

Previous studies have observed similar TR results between genders[3,5,28]. Ferreira[28] did not identify any differences between genders in junior judo athletes' TR using the Reaction Test (RT/S1). Badau *et al.*[3] also did not find any differences in TR between genders in volleyball players with an average age of 13.6 years using the Human Benchmark Test. Zak *et al.*[5] did not find any differences in TR between genders in young cyclists using the MCZR/TB 1.0 equipment (ATB Info-Elektro). On the other hand, other authors have claimed that there are differences in TR between genders[29,30]. Wierenga *et al.*[30] attributed the observed difference to possible imbalances in the effectiveness of the CNS, due to the different presentation of white and gray matter volume in the brain between sexes. This anatomical difference could lead to differentiation in myelination and synaptic density, being one of the mechanisms capable of explaining sex differences in CNS activation and consequently in TR performance. Dykiert *et al.*[29] report that this difference could be attributed to circulating levels of estrogen and testosterone hormones in the body, which could affect the brain differently in men and women. This mechanism would generate a difference in the speed of responses to simple and complex stimuli, which could explain the sexual differences in TR. However, these proposed mechanisms[29,30] was not confirmed by the results of the present study, suggesting the need for new studies to identify the mechanisms and parameters that could differentiate or not differentiate TR between sexes.

In this study, when comparing simple stimulus tests and choice tests, it was observed that the simple stimulus promoted TR and TTR than the choice stimulus, suggesting that TR may have a greater impact on TTR than TM, and that reflexive actions may be more relevant in response preparation. Similar results were identified by Zak *et al.*[5], who stated that choice reactions involve a decision-making process in which the individual needs to define their response after several stimulus options, triggering a process that slows them down by up to 100ms compared to simple stimulus. In our study, the difference between the simple stimulus and choice stimulus ranged from 14-25ms, demonstrating that this mechanism may explain the longer times found with the choice stimulus.

Considering that the TR may have a greater impact on the TTR, and that the TTR in a sports action is characterized by a post-stimulus choice response to react to opponent actions, and that this stimulus perception affects decision-making and can determine sports success, and that the SPEED equipment used in this study has the ability to detect the TR and TM fractions of TTR, these findings suggest that individual TR capacity may be a relevant assessment for the selection of sports talent, and that the SPEED equipment can be efficiently used for this purpose.

On the other hand, our study yielded a difference compared to the findings in the scientific literature, identifying that the choice stimulus promoted faster TM than the simple stimulus. Zar *et al.*[5] report that this difference may occur due to the assessment conditions and the level of task complexity. This scientific gap needs to be clarified with further studies.

For the dominant hand factor, no difference was observed between athletes with right and left dominant hands. These findings were similar to those observed by other authors[6]. However, they contradict previous studies that reported differences in response times for the dominant hand or foot[16,18,31] and that the right dominant hand would be faster than the left[17,20]. The inconsistency of literature results with those of the present study suggests the need for further research to assess the impact of right and left dominant hands on response times.

The methodological limitations of the study included conducting the testing sessions in a single day, which did not allow for the verification of result reproducibility, and the lack of identification of athletes' training levels to correlate with their performances in the tests. As an original result, the SPEED equipment was able to identify response times in its TR and TM fractions. This study was one of the first to compare response times between eye-hand and eye-foot coordination sports. Additionally, it identified shorter TM after the choice stimulus compared to the simple stimulus, which calls for further studies to evaluate the mechanisms and justifications for this result."

Conclusion

The results of this investigation allow us to conclude that, through the assessment of an eye-hand coordination task, volleyball athletes showed better performance in reaction and response times than futsal athletes, and male athletes exhibited better performance in movement and response times than female athletes.

In addition, it can be inferred that the simple stimulus resulted in shorter reaction and response times compared to the choice stimulus; among volleyball athletes, liberos exhibited superior performance to attackers, and among futsal athletes, goalkeepers had better performance than line players. Dominant hand did not affect the evaluated times.

The results of this investigation corroborate that the specificity of actions and training of athletes, along with the similarity of the evaluated task, impacted the parameters of response time assessed in this study.

References

1. Huerta Ojeda A, Lizama Tapia P, Pulgar Alvarez J, Gonzalez-Cruz C, Yeomans-Cabrera MM, Contreras Vera J. Relationship between Attention Capacity and Hand-Eye Reaction Time in Adolescents between 15 and 18 Years of Age. Int J Environ Res Public Health. 2022;19(17):10888. DOI: 10.3390/ijerph191710888.
2. Sirico F, Romano V, Sacco AM, Belviso I, Didonna V, Nurzynska D, et al. Effect of Video Observation and Motor Imagery on Simple Reaction Time in Cadet Pilots. J Funct Morphol Kinesiol. 2020;5(4):89. DOI: 10.3390/jfmk5040089.
3. Badau D, Stoica AM, Litoi MF, Badau A, Duta D, Hantau CG, et al. The Impact of Peripheral Vision on Manual Reaction Time Using Fitlight Technology for Handball, Basketball and Volleyball Players. Bioengineering (Basel). 2023;10(6):697. DOI: 10.3390/bioengineering10060697.
4. Silva SL, Neto EG, Palma GCS, Silva Filho AS, Corrêa UC. The anticipatory and reaction time behaviors of the futsal goalkeeper. J Phys Educ. 2021;32:e3218. DOI: 10.4025/jphyseduc.v32i1.3218.
5. Zak M, Mikrut G, Sobota G. Measurement of Simple Reaction Time of the Cyclist in the Laboratory and Natural Environment Condition. Sensors (Basel). 2023;23(8):3898. DOI: 10.3390/s23083898.

6. Lakshminarayanan K, Ramu V, Rajendran J, Chandrasekaran KP, Shah R, Daulat SR, et al. The Effect of Tactile Imagery Training on Reaction Time in Healthy Participants. Brain Sci. 2023;13(2):321. DOI: 10.3390/brainsci13020321.
7. Teixeira M, Medeiros AIA, Simim MAM, Assumpção CO. Young soccer players with higher somatic maturation are stronger, more powerful and faster than those with lower maturation. J Phys Educ. 2021;32:e3258. DOI: 10.4025/jphyseduc.v32i1.3258.
8. Otero I, Alonso P. Cognitive reflection test: The effects of the items sequence on scores and response time. PLoS One. 2023;18(1):e0279982. DOI: 10.1371/journal.pone.0279982.
9. Spierer DK, Petersen RA, Duffy K, Corcoran BM, Rawls-Martin T. Gender influence on response time to sensory stimuli. J Strength Cond Res. 2010;24(4):957-63. DOI: https://doi.org/10.1519/jsc.0b013e3181c7c536
10. Sadler CM, Peters KJ, Santangelo CM, Maslovat D, Carlsen AN. Retrospective composite analysis of StartReact data indicates sex differences in simple reaction time are not attributable to response preparation. Behav Brain Res. 2022;426:113839. DOI: 10.1016/j.bbr.2022.113839.
11. Nieczuja-Dwojacka J, Marchewka J, Siniarska A, Budnik A, Popielarz K, Tabak I. Influence of body build on hand grip strength, simple reaction time and strength of the abdominal muscles in prepubertal children. Anthropol Anz. 2023;80(2):151-8. DOI: 10.1127/anthranz/2023/1591.
12. Ervilha UF, Silva VF, Araújo RC, Mochizuki L, Hamill J. Elite female tae kwon do athletes have faster reaction time and longer movement time than males during a striking kick. Arch Budo Sci Martial Arts Extreme Sports. 2014[acessed 2024 Jul 7];10:1-9. Available from:: https://files.4medicine.pl/download.php?cfs_id=1080.
13. Assis MEF, Noce F, Cândido FA, Diniz ACR, Lopes MAC, Melo CC. Comparação do tempo de reação em atletas de futsal. Rev Bras Futsal Futebol. 2021[acessed 2024 Jul 7];13(56):738-44. Available from:: http://www.rbff.com.br/index.php/rbff/article/view/905.
14. García-de-Alcaraz A, Usero L. Influence of Contextual Variables on Performance of the Libero Player in Top-Level Women's Volleyball. J Hum Kinet. 2019;70:199-207. DOI: 10.2478/hukin-2019-0032.
15. Crocetta TB, Liz CM, Souza JOC, Viana MS, Andrade A. Motivação e tempo de reação de universitários praticantes e não praticantes de exercícios físicos. Rev Bras Educ Fís Esporte. 2020;34(1):177-85. DOI: http://dx.doi.org/10.11606/1807-5509202000010177.
16. Flores FS, Lourenco J, Phan L, Jacobs S, Willig RM, Marconcin PEP, et al. Evaluation of Reaction Time during the One-Leg Balance Activity in Young Soccer Players: A Pilot Study. Children (Basel). 2023;10(4):743. DOI: 10.3390/children10040743.
17. Fernandes LA, Alves WT, Ribeiro SRO, Figueiredo LS, Ambrósio NFA, Couto CR, et al. Comparação da destreza manual em indivíduos com lateralidade distinta. Cad Educ Fís Esporte. 2021;19(1):41-7. DOI: 10.36453/cefe.2021191.a26831.
18. Fuelscher I, Hyde C, Efronb D, Silk TJ. Manual dexterity in late childhood is associated with maturation of the corticospinal tract. NeuroImage. 2021;226:117583. DOI: 10.1016/j.neuroimage.2020.117583.
19. Churchill NW, Hutchison MG, Graham SJ, Schweizer TA. Brain function associated with reaction time after sport-related concussion. Brain Imaging Behav. 2021;15(3):1508-17. DOI: 10.1007/s11682-020-00349-9.
20. Dexheimer B, Przybyla A, Murphy TE, Akpinar S, Sainburg R. Reaction time asymmetries provide insight into mechanisms underlying dominant and non-dominant hand selection. Exp Brain Res. 2022;240(10):2791-802. DOI: 10.1007/s00221-022-06451-2.
21. Farkas BC, Krajcsi A, Janacsek K, Nemeth D. The complexity of measuring reliability in learning tasks: An illustration using the Alternating Serial Reaction Time Task. Behav Res Methods. 2023. DOI: 10.3758/s13428-022-02038-5.
22. Marinello KCV, Pereira MC, Rocha Junior VA, Medeiros FVA, Teles FS, Coutinho SMG, et al. Avaliação do tempo de reação em crianças com anemia falciforme. Motricidade. 2021;17(1):7-14. DOI: 10.6063/motricidade.18935.
23. Hanumantha S, Kamath A, Shastry R. Diurnal Variation in Visual Simple Reaction Time between and within Genders in Young Adults: An Exploratory, Comparative, Pilot Study. Sci World J. 2021;6695532:1-5. DOI: https://doi.org/10.1155/2021/6695532.
24. Maslovat D, Klapp ST, Forgaard CJ, Chua R, Franks IM. The effect of response complexity on simple reaction time occurs even with a highly predictable imperative stimulus. Neurosci Lett. 2019;704:62-6. DOI: 10.1016/j.neulet.2019.03.056.
25. Maciel RN, Morales AP, Barcelos JL, Nunes WJ, Azevedo MMA, Silva VF. Relação entre tempo de reação e função específica em jogadores de voleibol. Rev Fit Perform. 2009;8(6):395-9. DOI: 10.3900/fpj.8.6.395.p

26. Ruschel C, Haupenthal A, Hubert M, Fontana HB, Pereira SM, Roesler H. Tempo de reação simples de jogadores de futebol de diferentes categorias e posições. Motricidade. 2011;7(4):73-82. DOI: http://dx.doi.org/10.6063/motricidade.7(4).90
27. Silva TMR, Pinheiro CJB, Campos YS, Lobão TA, Lima CIS, Gouveia A. Eficácia de processos sensório-motores e parâmetros morfofuncionais em jovens adultos – sedentários e atletas de taekwondo: um estudo transversal. J Phys Educ. 2022;91:47-55. DOI: 10.37310/ref.v91i1.2815.
28. Ferreira TV. Comparação por sexo entre o tempo de reação simples, o tempo de reação complexo e a impulsividade de atletas da seleção brasileira de judô da categoria júnior [dissertação]. Belo Horizonte: Universidade Federal de Minas Gerais; 2017[acessed 2024 Jul 7]. Available from: https://repositorio.ufmg.br/handle/1843/EEFF-BB9HWN
29. Dykiert D, Der G, Starr JM, Deary IJ. Age differences in intra-individual variability in simple and choice reaction time: systematic review and meta-analysis. PLoS One. 2012;7(10):e45759. DOI: 10.1371/journal.pone.0045759.
30. Wierenga LM, Sexton JA, Laake P, Giedd JN, Tamnes CK, Pediatric Imaging, et al. A Key Characteristic of Sex Differences in the Developing Brain: Greater Variability in Brain Structure of Boys than Girls. Cereb Cortex. 2018;28(8):2741-51. DOI: 10.1093/cercor/bhx154.
31. Tzourio-Mazoyer N, Labache L, Zago L, Hesling I, Mazoyer B. Neural support of manual preference revealed by BOLD variations during right and left finger-tapping in a sample of 287 healthy adults balanced for handedness. Laterality. 2021;26(4):398-420. DOI: https://doi.org/10.1080/1357650x.2020.1862142.

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